CLAIMS

1. A high dimensional accuracy pipe manufactured by a push-to-pass process comprising the steps of pushing at least one metal pipe in a hole provided in a die while a plug is being charged in the metal pipe, and allowing the metal pipe to pass through the hole, wherein at least one of the deviation of the outside diameter, the deviation of the inside diameter, and the deviation of the thickness in the circumferential direction of the pipe as processed is 3.0% or less.

2. The high dimensional accuracy pipe according to Claim 1, which is manufactured by a push-to-pass process comprising the steps of pushing at least one metal pipe in a hole provided in a die while a plug is being charged in the pipe, and allowing the metal pipe to pass through the hole so that the thickness of the metal pipe at an outlet side of the die is not more than that at an inlet side, wherein at least one of the deviation of the outside diameter, the deviation of the inside diameter, and the deviation of the thickness in the circumferential direction of the pipe as processed is 3.0% or less.

3. The high dimensional accuracy pipe according to Claim 1 or 2, wherein the push-to-pass process is performed while the metal pipe is being in contact with the entire outer circumference of the plug and with the entire inner circumference of the die in the same cross-section of the metal pipe.

4. The high dimensional accuracy pipe according to one of

Claims 1 to 3, wherein the die is an all-in-one type and/or a fixed type die.

5. A method for manufacturing a high dimensional accuracy pipe, comprising a push-to-pass process which comprises the step of pushing at least one metal pipe in a hole provided in a die while a plug is being charged in the metal pipe, and allowing the metal pipe to pass through the hole.

6. The method for manufacturing a high dimensional accuracy pipe, according to Claim 5, wherein the thickness of the pipe at an outlet side of the die is set not more than that at an inlet side thereof.

7. The method for manufacturing a high dimensional accuracy pipe, according to Claim 5 or 6, wherein the push-to-pass process is performed while the metal pipe is being in contact with the entire outer circumference of the plug and with the entire inner circumference of the die in the same cross-section of the metal pipe.

8. The method for manufacturing a high dimensional accuracy pipe, according to one of Claims 5 to 7, wherein the die is an all-in-one type and/or a fixed type die.

9. The method for manufacturing a high dimensional accuracy pipe, according to one of Claims 5 to 8, wherein the plug is a floating plug.

10. A highly efficient method for manufacturing a high dimensional accuracy pipe, wherein, in Claim 5, when at least one of the deviation of the outside diameter, the deviation of the inside diameter, and the deviation of the thickness in the circumferential direction of each of the pipes is improved by

the push-to-pass process, the pipes are continuously fed in the die using pipe feeding means provided at an inlet side of the die while the plug is being charged in each of the pipes and is being floated.

11. The highly efficient method for manufacturing a high dimensional accuracy pipe, according to Claim 10, wherein the pipe feeding means is at least one caterpillar holding the pipes before they are processed.

12. The highly efficient method for manufacturing a high dimensional accuracy pipe, according to Claim 10, wherein the pipe feeding means is at least one endless belt holding the pipes before they are processed.

13. The highly efficient method for manufacturing a high dimensional accuracy pipe, according to Claim 10, wherein the pipe feeding means is at least one intermittent feeding device which alternately holds and intermittently feeds the pipes before they are processed.

14. The highly efficient method for manufacturing a high dimensional accuracy pipe, according to Claim 10, wherein the pipe feeding means is a press which sequentially pushing the pipes before they are processed.

15. The highly efficient method for manufacturing a high dimensional accuracy pipe, according to Claim 10, wherein the pipe feeding means is at least one grooved roll holding the pipes before they are processed.

16. The highly efficient method for manufacturing a high dimensional accuracy pipe, according to Claim 15, wherein the number of said at least one grooved roll is at least two.

17. The highly efficient method for manufacturing a high dimensional accuracy pipe, according to Claim 15 or 16, wherein at least two stands each having the grooved roll are provided.

18. A method for manufacturing a high dimensional accuracy pipe having superior surface quality, wherein, in Claim 5, after an interior and/or an exterior surface of the pipe is provided with a lubricant film, the plug is charged in the pipe, and the push-to-pass process is performed using the die.

19. The method for manufacturing a high dimensional accuracy pipe having superior surface quality, according to Claim 18, wherein the pipe on which the lubricant film is formed is a steel pipe to which oxide scales still adhere.

20. The method for manufacturing a high dimensional accuracy pipe having superior surface quality, according to Claim 18 or 19, wherein the lubricant film is formed by using a liquid lubricant.

21. The method for manufacturing a high dimensional accuracy pipe having superior surface quality, according to Claim 18 or 19, wherein the lubricant film is formed by using a grease-based lubricant.

22. The method for manufacturing a high dimensional accuracy pipe having superior surface quality, according to Claim 18 or 19, wherein the lubricant film is formed by using a drying resin.

23. The method for manufacturing a high dimensional accuracy pipe having superior surface quality, according to Claim 22, wherein the lubricant film is formed by the steps of

applying the drying resin, a liquid containing the drying resin diluted with a solvent, or an emulsion of the drying resin, and then supplying a hot wind or performing air drying.

24. A method for manufacturing a high dimensional accuracy pipe, wherein, in Claim 5, in a high dimensional accuracy pipe manufacturing method for manufacturing pipes having a predetermined size and different degrees of processing with high dimensional accuracy from raw pipes having the same size, a plug capable of expanding the pipes and reducing the diameters thereof is charged in the pipes, and the push-to-pass process is performed for the pipes using the die.

25. The method for manufacturing a high dimensional accuracy pipe, according to Claim 24, wherein the plug is floated in the pipes, and the pipes are continuously supplied to the die.

26. The method for manufacturing a high dimensional accuracy pipe, according to Claim 24 or 25, wherein the plug is a plug in which a corn angle at a pipe expanding portion is set to be smaller than a corn angle at a diameter reducing portion.

27. The method for manufacturing a high dimensional accuracy pipe, according to one of Claims 24 to 26, wherein a target outside diameter of the pipe at an outlet side of the die is set to be smaller than the outside diameter of the pipe at an inlet side of the die.

28. A stable method for manufacturing a high dimensional accuracy pipe, wherein, in Claim 5, in manufacturing a high dimensional accuracy pipe by the push-to-pass process in which,

while the plug is being charged in the pipe, the pipe is pushed in the hole provided in the die and is then allowed to pass therethrough, a plug having an angle of 5 to 40° which is formed between the surface of a diameter reducing portion and a processing central axis and a length of 5 to 100 mm of the diameter reducing portion is used as the plug, and as the die, a die is used having an angle of 5 to 40° which is formed between the interior surface of the hole at an inlet side and the processing central axis.

29. The stable method for manufacturing a high dimensional accuracy pipe, according to Claim 28, wherein the length of a bearing portion of the plug is set to 5 to 200 mm.

30. The stable method for manufacturing a high dimensional accuracy pipe, according to Claim 28 or 29, wherein the thickness of the pipe at an outlet side of the die is set to be not more than that at an inlet side thereof.

31. The stable method for manufacturing a high dimensional accuracy pipe, according to one of Claims 28 to 30, wherein as the die, an all-in-one fixed type die is used.

32. The stable method for manufacturing a high dimensional accuracy pipe, according to Claim 28 or 31, wherein the plug is being floated in the pipe.

33. A stable method for manufacturing a high dimensional accuracy pipe, wherein, in Claim 5, in manufacturing a high dimensional accuracy pipe by the push-to-pass process in which, while the plug is being charged in the pipe and is being floated, the pipe is pushed in the hole provided in the die and is then allowed to pass therethrough, during the push-to-

pass process, a load in a push-to-pass direction is measured, the measured load is compared with a calculated load calculated using one of the following [equation 4] to [equation 6] obtained from material properties of a raw pipe, which is a pipe before processing, and the continuation of the push-to-pass process is determined based on the result of the comparison;

Note

[Equation 4] σ_k × the cross-section of a raw pipe

In the above equation, $\sigma_k = YS \times (1-a \times \lambda)$, $\lambda = (L/\sqrt{n})/k$, a=0.00185 to 0.0155, L represents the length of the raw pipe, k represents the secondary radius of the cross-section, $k^2 = (d_1^2 + d_2^2)/16$, n represents pipe end conditions (n=0.25 to 4), d_1 represents the outer diameter of the raw pipe, d_2 represents the inner diameter of the raw pipe, and YS represents a yield strength of the raw pipe;

[Equation 5] yield strength YS of the raw pipe × the cross-section of the raw pipe; and

[Equation 6] tensile strength TS of the raw pipe × the cross-section of the raw pipe.

34. The stable method for manufacturing a high dimensional accuracy pipe, according to Claim 33, wherein, when the measured load is not more than the calculated load, it is determined that the continuation can be performed, so that the process is continued as it has been, and when the measured load is more than the calculated load, after it is determined that the continuation cannot be performed, and the process is then interrupted so that the die and/or the plug is exchanged

with a new one which has a different shape in conformity with the same pipe product dimensions, the process is restarted.

35. The stable method for manufacturing a high dimensional accuracy pipe, according to Claim 34, wherein the die and the plug to be used after the exchange have angles smaller than those of the die and the plug used before the exchange.

36. The stable method for manufacturing a high dimensional accuracy pipe, according to one of Claims 33 to 35, wherein a lubricant is applied onto the raw pipe before the push-to-pass process, and only when the measured load exceeds the calculated load, the type of lubricant is changed.

37. A manufacturing apparatus for manufacturing a high dimensional accuracy pipe, comprising: a plug capable of being in contact with the entire inner circumference of at least one metal pipe, at least one die having a hole capable of being in contact with the entire outer circumference of the metal pipe, and a pipe pushing device pushing the metal pipe, wherein while the plug is being charged in the metal pipe, the metal pipe is pushed in the hole in the die and is then allowed to pass therethrough, whereby the push-to-pass process is performed.

38. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to Claim 37, wherein the die is an all-in-one type and/or a fixed type die.

39. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to Claim 37 or 38, wherein the plug is a floating type plug.

40. The manufacturing apparatus for manufacturing a high

dimensional accuracy pipe, according to one of Claims 37 to 39, wherein the pipe pushing device is a device continuously pushing the metal pipes.

41. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to one of Claims 37 to 39, wherein the pipe pushing device is a device intermittently pushing the metal pipes.

42. A highly efficient manufacturing method for manufacturing a high dimensional accuracy pipe, wherein, in Claim 37, in a manufacturing method for manufacturing a high dimensional accuracy pipe, in which a plug is charged in pipes and is floated, and the pipes are continuously or intermittently pushed in a die and are then allowed to pass therethrough so as to perform a push-to-pass process, a plurality of dies having different hole shapes is arranged along the same circumference, and one of the dies in conformity with product dimensions is moved in the circumference direction of the arrangement and is disposed in a pass line so that the push-to-pass process is performed.

43. A highly efficient manufacturing method for manufacturing a high dimensional accuracy pipe, wherein, in Claim 37, in a manufacturing method for manufacturing a high dimensional accuracy pipe, in which a plug is charged in pipes and is floated, and the pipes are continuously or intermittently pushed in a die and are then allowed to pass therethrough so as to perform a push-to-pass process, a plurality of dies having different hole shapes is arranged on the same linear line, and one of the dies in conformity with

product dimensions is moved in the linear line direction of the arrangement and is disposed in a pass line so that the push-to-pass process is performed.

44. The highly efficient manufacturing method for manufacturing a high dimensional accuracy pipe, according to Claim 42 or 43, wherein when production dimensions for the following pipe are changed from those for the preceding pipe, after the push-to-pass process for the preceding pipe is performed, the following pipe is allowed to stay at an inlet side of the die, and before or after a die in conformity with the production dimensions for the following pipe is moved or while the die is being moved, a plug in conformity with the same production dimensions is charged in the following pipe.

45. A highly efficient manufacturing apparatus for manufacturing a high dimensional accuracy pipe, wherein, in claim 37, the dies through which the pipes are allowed to pass, the pushing device pushing the pipes in a die placed in a pass line, and a die rotating platform are provided, the die rotating platform supporting the dies arranged in the same circumference and moving one of the dies in a circumference direction to dispose it in the pass line.

46. A highly efficient manufacturing apparatus for manufacturing a high dimensional accuracy pipe, wherein, in claim 37, the dies through which the pipes are allowed to pass, the pushing device pushing the pipes in a die placed in a pass line, and a die linear-driving platform are provided, the die linear-driving platform supporting the dies arranged on the same linear line and moving one of the dies in a linear line

direction to dispose it in the pass line.

47. A manufacturing method for manufacturing a high dimensional accuracy pipe, wherein, in Claim 5, in a manufacturing method for manufacturing a high dimensional accuracy pipe by the push-to-pass process in which, while the plug is charged in the pipe and is floated, the pipe is pushed in the die and is then allowed to pass therethrough, the pipe at an outlet side of the die is allowed to pass through a hole body provided at a position which is very close to the outlet side of the die and which is adjusted beforehand in the plane perpendicular to a pipe traveling direction, whereby pipe bending is prevented.

48. The manufacturing method for manufacturing a high dimensional accuracy pipe, according to Claim 47, wherein the pipe at an inlet side of the die and/or an outlet side of the hole body is allowed to pass through a guide tube.

49. The manufacturing method for manufacturing a high dimensional accuracy pipe, according to Claim 47 or 48, wherein the pipes are continuously pushed in the die.

50. A manufacturing apparatus for manufacturing a high dimensional accuracy pipe, wherein, in Claim 37, in a manufacturing apparatus having the die through which the pipe is allowed to pass, and the pushing device pushing the pipe in the die, fine adjustment means for adjusting pipe bending is provided at a position very close to an outlet side of the die, the means having a hole body through which the pipe is allowed to pass, a support substrate supporting the hole body movably in the plane perpendicular to a pipe traveling direction, and

a hole body-moving mechanism which is supported by the support substrate and which moves the hole body.

51. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to Claim 50, wherein the hole body-moving mechanism is a mechanism in which at least one place of a peripheral portion of the hole body is pushed in the direction perpendicular to the pipe traveling direction by a tapered surface of a wedge-shaped mold which is moved in the pipe traveling direction.

52. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to Claim 51, wherein the movement of the wedge-shaped mold is biased by a screw.

53. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to Claim 50, wherein the hole body-moving mechanism is in accordance with a pushing or a pulling method in which at least one place of a peripheral portion of the hole body is directly pushed or pulled in the direction perpendicular to the pipe traveling direction.

54. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to Claim 53, wherein the pushing or pulling of the pushing or pulling method is biased by a fluid pressure cylinder.

55. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to one of Claims 50 to 54, wherein the diameter of a hole provided in the hole body is not less than the diameter of the hole in the die at the outlet side.

56. The manufacturing apparatus for manufacturing a high

dimensional accuracy pipe, according to one of Claims 50 to 55, wherein the hole in the hole body is a straight hole or a tapered hole.

57. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to one of Claims 50 to 56, wherein at least one guide tube is further provided, through which the pipe at an inlet side of the die and/or an outlet side of the fine adjustment means for adjusting pipe bending is allowed to pass.

58. The manufacturing apparatus for manufacturing a high dimensional accuracy pipe, according to one of Claims 50 to 57, wherein the pushing device is a continuous pushing device capable of continuously pushing the pipes.

59. A manufacturing line for manufacturing a high dimensional accuracy pipe, comprising the push-to-pass process device described in Claim 37, wherein a pipe-end grinding device grinding the end surface of the pipe in the direction perpendicular to a pipe axis, a lubricant immersion coating bath in which the pipe is coated with a lubricant by immersion, a drying device drying the pipe coated with the lubricant, and the push-to-pass process device are provided in that order.

60. The manufacturing line for manufacturing a high dimensional accuracy pipe, according to Claim 59, wherein a cutting device cutting the pipe into short pipes is further provided at an inlet side of the pipe-end grinding device.

61. The manufacturing line for manufacturing a high dimensional accuracy pipe, according to Claim 59 or 60, wherein, instead of the lubricant immersion coating bath and

the drying device, at an inlet side of the die of the push-to-pass process device, a lubricant spray coating device for coating the pipe with a lubricant by spraying or a lubricant spray coating and drying device in which the pipe is coated with a lubricant by spraying and is then dried is provided.

62. The manufacturing line for manufacturing a high dimensional accuracy pipe, according to one of Claims 59 to 61, wherein, in addition to the push-to-pass process device, at least one of a die exchange device exchanging the die, a plug exchange device exchanging the plug, and a bending prevention device preventing pipe bending at an outlet side of the die is provided.